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(54) Multiple output switching power supply having one controlled output voltage and load compensation.

(57) Multiple output switching power supply having one controlled output and load compensation, where periodical voltage pulses, induced in at least two secondary windings of a transformer, load two buffer capacitive elements, each connected between ground and respectively a first and a second output terminal at two different, equal sign voltages and makes available two output voltages V1, V2, one of which (V1) is controlled, at a first and a second output terminal respectively, and where the capacitive element connected between ground and the first

terminal comprises two series connected capacitors having a value such that a voltage slightly higher than V2 in absolute value is imparted to the node common to the two capacitors, said node being connected to the second output terminal through a diode conductive in the direction which allows the electric charge stored in the first capacitive element to flow towards the second terminal and the second capacitive element when the output voltage V2 decreases in absolute value.

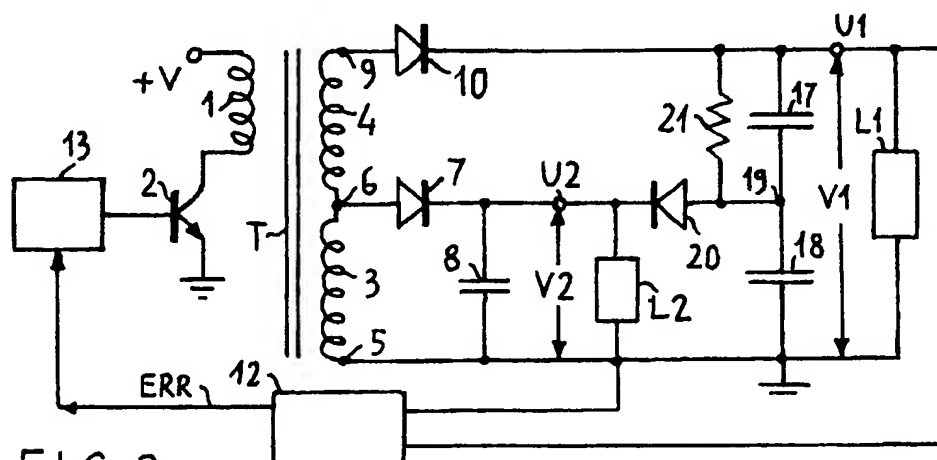


FIG.3

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349-MULTIPLE OUTPUT SWITCHING POWER SUPPLY HAVING ONE CONTROLLED OUTPUT VOLTAGE AND LOAD COMPENSATION.

The present invention relates to multiple output switching power supplies having one controlled output voltage.

Multiple outputs switching power supplies are known in which an unregulated DC voltage (obtained in case from a rectified AC voltage source) is periodically applied through switches to the primary winding of a transformer, so as to induce voltage pulses in a plurality of secondary windings.

The induced voltage pulses charge, through diodes, some capacitors connected to the output of the secondary windings.

The capacitors act as buffer filters and relatively constant DC voltages are available at their ends.

These voltages may be used to power loads.

By comparing the voltage available at the ends of one of such capacitors with a reference voltage, an error signal is obtained which is used to control, through switcheable devices, the frequency and/or the duty cycle of the voltage and current pulses applied to the primary winding, so as to regulate the voltage at the terminals of one capacitor, thus of one output.

Missing any independent control circuit for the other outputs, the charge voltage of the other capacitors, hence the voltage available at the other outputs, is indirectly regulated and is largely affected by the load conditions of the several outputs both in static as well as transient situations.

To overcome this disadvantage several solutions are known.

They will be detailly considered in the following but in any event they are not completely satisfactory, particularly in dynamic conditions of load variation.

One of these solutions provides for a series connection among outputs and requires the use of components sized to sustain the sum of the loads connected to the outputs.

In addition the voltage ripple which affects the indirectly regulated output is the sum of the intrinsic ripple voltage and the one affecting the regulated output.

Further in case of transient load peaks at the regulated output, a relevant voltage drop occurs at the indirectly regulated output. These drawbacks are overcome by the multiple output power supply of the invention where the filter and buffer capacitance of a first regulated voltage output, higher than a second voltage of a second unregulated output, is comprised of two series connected capacitors.

The capacity of the two capacitor is selected so as to obtain, at the connection node of the two capacitors, a voltage equal to or slightly higher than the voltage at the second output.

The node connecting the two capacitors is connected to the second output through a diode which enables power flowing from one of the capacitors to the second output if the voltage at the second output decreases.

The diode prevents coupling of the outputs if the voltage at the regulated output decreases, due to load peaks.

The features and the advantages of the invention will appear more clearly from the following description of a preferred form of embodiment and from the enclosed drawings where:

- Figure 1 is a block diagram of a first multiple output power supply known from the prior art.
- Figure 2 is a block diagram of a second multiple output power supply known from the prior art.
- Figure 3 is a block diagram of a preferred form of embodiment of a multiple output power supply according to the present invention.

Figure 1 shows a multiple output power supply known from the prior art. An unregulated DC voltage +V is input to a terminal of a primary winding 1 of a transformer T.

The other terminal is periodically connected to ground through a switching transistor 2.

Two secondary windings 3,4 of the transformer are series connected each to the other.

A terminal 5 of secondary winding 3 is grounded.

Node 6, common to the two secondary windings, is connected to the anode of diode 7, whose cathode is connected to an output terminal U2.

A capacitor 8 is connected between terminal U2 and ground.

The terminal 9 of secondary winding 4 is connected to the anode of a diode 10, whose cathode is connected to an output terminal U1.

A capacitor 11 is connected between U1 and ground.

The voltage/current pulses induced in the secondary windings 3,4 charge the capacitors at a voltage level V1,V2, respectively appearing between output terminals U1,U2 and ground.

A comparator circuit 12 receives voltage V1, compares it with a reference voltage and generates an error signal ERR, which is forwarded to a control logic 13.

The control logic 13 applies a control signal to the base of transistor 2.

This signal controls the frequency or the duty cycle of the voltage pulses applied to the primary winding thus regulating voltage V1 at a predetermined value.

It is clear that for predetermined load conditions L1, L2 on the outputs the ratio $V1/V2$ between the two output voltages is equal to the ratio between the turn number of the secondary winding 3 and the sum of the turn numbers of the windings 3 and 4.

Therefore voltage V2 is indirectly regulated.

However if the load L1 decreases below a predetermined value, whilst load L2 is not changed, voltage V2 drops below the indirect regulation value.

At the extreme, if load L1 is zero and power waste in the components is neglected, no power has to be transferred to capacitor 11 and the frequency or the duty cycle of the voltage pulses induced in the secondary windings must virtually drop to zero.

As a consequence voltage V2 virtually drops to zero.

By reverse V2 largely rises above a nominal indirect regulation value if L2 decreases (at load L1 non zero).

Normally a power supply as the described one finds use in equipments where the loads powered by the two outputs are relatively constant. Power supplies of this kind are also used in data processing system peripheral units, such as printers, diskette drivers, and like.

In these units the voltage V2, of low value and generally of +5V, is used to power a relatively constant load consisting in logic control circuits.

Voltage V1, having an higher value and typically comprised between +15 and +40 V, is used to feed power devices such as motors and electromagnetic actuators, which constitute broadly variable loads.

In this case and in order to avoid broad changes in voltage V2 depending on load L1, it is essential to assure that L1 is kept relatively constant.

This is obtained by connection of a fixed resistive load R1 between terminal U1 and ground, so that the relative change of the total load $R1 + L1$ is contained within acceptable limits.

It is clear that such arrangement reduces the efficiency of the power supply, requires an oversizing and causes power waste and development of heat which must be dissipated.

Figure 2 shows a second arrangement known from the prior art, which provides a partial solution of the problem.

Since this arrangement is very similar to the one shown in fig. 1 equivalent elements in both figures are referenced with the same numerals.

In figure 2 terminal 5 of secondary winding 3 is grounded.

The other terminal 14 is connected to the anode of diode 7, whose cathode is connected to terminal U2. A capacitor 8 is connected between U2 and ground.

Terminal 15 of secondary winding 4 is connected to U2.

The other terminal 9 is connected to the anode of diode 10, whose cathode is connected to output terminal U1.

A capacitor 16 is connected between terminals U1, U2.

The voltage V1, available between terminal U1 and ground is the sum of the charging voltage of the two capacitors 16, 8 and is input to comparator 12.

Even in this case voltage V1 is directly regulated and voltage V2 is indirectly regulated.

By this arrangement the two outputs are dynamically coupled: every change in voltage V2 affects voltage V1 too so that the indirect regulation is more effective.

As a drawback, the diode 7 must supply the full current required to feed both load L2 both load L1. Therefore it must be largely sized. Further the output U2 is affected by the ripple voltage due to the impulsive loading of capacitor 8 and in addition by the whole ripple voltage affecting output U1 (capacitor 8 receives power needed by load L1 and transfers such power to load L1).

This ripple voltage may be unacceptable if, as it is often the case, most of the power must be supplied to output U1, which is at a voltage higher than V2.

A ripple voltage in the order of 5% at an output averaging 30 V (equal to 1,5V in absolute value), when transferred to an output averaging 5V, results in a ripple voltage in the order of 30% hence unacceptable. A further inconvenient occurs in case power peaks are drain from output U1, which peaks may exceed the maximum regulating range of the power supply.

Temporary overloads are a normal event in the operation of computer peripheral units because it is against economy to size a power supply in order to perform regulation even in case of temporary overloading. In these circumstances, voltage V1 may fall well below the normal regulation value and causes a corresponding decrease of voltage V2. If the decrease of V1 may be tolerated, the decrease in V2 may hamper the correct operation of the logical circuits.

These drawbacks are overcome by the embodiment of Fig. 3, where the elements functionally equivalent to the ones of the preceding figures are referenced by the same numbers.

In Fig. 3 the secondary winding 3 is series

connected to secondary winding 4 (as in Fig. 1).

The terminals 5 of secondary winding 3 is grounded and the common node of the two secondary windings is connected to the anode of a diode 7, whose cathode is connected to output U2.

A capacitor 8 is connected between U2 and ground.

The terminal 9 of secondary winding 4 is connected to the anode of diode 10, whose cathode is connected to the output terminal U1. A capacitive element consisting in two series connected capacitors 17,18 is connected between terminal U1 and ground.

Voltage V1, available between terminal U1 and ground is input to comparator circuit 12, which forwards an error signal to the control circuits 13 of the switching transistor 2.

Even in this case voltage V1 is directly regulated and voltage V2 is indirectly regulated.

The node 19, common to the two capacitors 17,18 is connected to the anode of a diode 20, whose cathode is connected to terminal U2. The capacitance of the two capacitors 17 and 18 is selected so that the voltage at node 19 is equal or slightly higher than voltage V2. This result can be easily obtained because is well known that a charging voltage applied to two series connected capacitors is distributed between the two capacitor so that the ration of the charge voltages is inversely proportional to the ration of the respective capacitances.

In this way, even if no load L1 or a minimum load L1 is connected to output U1, any voltage decrease at terminal U2 causes the forward biasing of diode 20 and a current flow from node 19 which tends to discharge capacitor 18, thus decreasing the value of V1.

In other words a fraction of the power required by load L2, which is not supplied by capacitor 8, is supplied by capacitor 18 which sustains voltage V1 and causes the intervention of the control circuits, which increase the power transferred from primary to secondary windings, in order to keep voltage V1 at the regulation level.

Diode 7 may be sized to sustain the maximum load L2 and is not required to sustain in addition the maximum load L1 as in case of Fig. 2. Moreover the ripple voltage of U1 is transferred to output U2 at a reduced extent only.

First because only a fraction of the ripple voltage equal to the ration between the voltage at node 12 ($\approx V2$) and voltage V1 is applied to the anode of diode 20 and second because this fraction is largely clipped by the diode (as a limit, when the diode is non conductive the filtering it total).

In case of temporary overload at output U1 and V1 voltage drop as to regulation value, diode 20 is reverse biased and no energy transfer occurs from

capacitor 8 towards capacitor 18.

Therefore V2 does not collapses.

It must be noted that voltage at node 19, relative to voltage V1 is univocally defined by the capacitance of capacitors 17,18 only in case of perfect capacitors.

In practice, real capacitors always exhibit a small leakage current and act as perfect capacitors having a resistance in parallel.

This fact may cause a drift of the voltage at node 19.

To prevent node 19 from dropping below a predetermined voltage value V2 it is possible to connect a resistor 21 in parallel to capacitor 17. The value of such resistor which may be very high, is selected so that the voltage applied to its terminals causes a current flow having the same order of magnitude of the maximum foreseeable leakage current of capacitor 18.

In this way voltage at node 19 is certainly kept at the level of voltage V2, plus the voltage drop in diode 20, except in case of transient overloads.

It is clear that the preceding description relates to a preferred embodiment and that several changes can be made.

In particular the circuits which convert an unregulated DC voltage in voltage pulses applied by means of a transformer to two filtering buffer elements which sustain the voltage at two outputs are examples only.

It is clearly possible to use control circuits which apply voltage pulses of opposite value to the primary winding of a transformer. It is also possible to apply voltage pulses of opposite direction to either one or the other of two primary windings depending on the direction of the pulses.

In both cases voltage pulses of opposite polarity are obtained at the secondary windings.

These pulses may be rectified with diode bridges and may be input to output filtering and buffering capacitors.

As in the case of the primary winding the secondary windings too may consists in two half windings coupled to diode half-bridges for rectifying the voltage pulses of opposite polarity induced in the half windings and for inputting them to the output filtering capacitors. Therefore the invention may be used in all kind of power supplies where voltage pulses input to a transformer primary winding induce voltage pulses in secondary windings, the induced voltage pulses charging at least two capacitive filtering elements which sustain two distinct output voltages, one of which provides a feedback signal for controlling parameters of the input pulses, such as frequency and/or duty cycle, thus achieving regulation of one of the two output voltages.

It is also clear that even if reference has been

made, in the description, to positive voltages, the invention may be used even in case of negative voltages, by reversing the conductive direction of the diodes in the circuit.

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Claims

1) Multiple output switching power supply providing a first directly controlled output voltage between a first output and ground and indirect control of at least a second output voltage between a second output and ground, comprising a transformer having at least a primary winding and at least two secondary windings, periodical voltage pulses being induced in said secondary windings, said voltage pulses loading, through rectifying elements, a first capacitive element, having a grounded terminal, at a first voltage V1 and a second capacitive element, having a grounded terminal, at a second voltage V2, equal in sign to V1 but having a lower value, said voltages being available, for loads powering, respectively at said first output and at said second output,

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characterized in that said first capacitive element comprises a first and a second capacitor, series connected between said first output and ground, the node common to said first and second capacitor being connected to said second output through a diode, said first and second capacitors having a value such that said first voltage applies to said node a voltage level equal or slightly higher, in absolute value, than said second voltage, said diode being conductive in the direction which allows power flow from said first capacitive element to said second output terminal and said second capacitive element.

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2) Power supply as in claim 1 comprising a resistor connected between said first output and said node common to said first and second capacitor.

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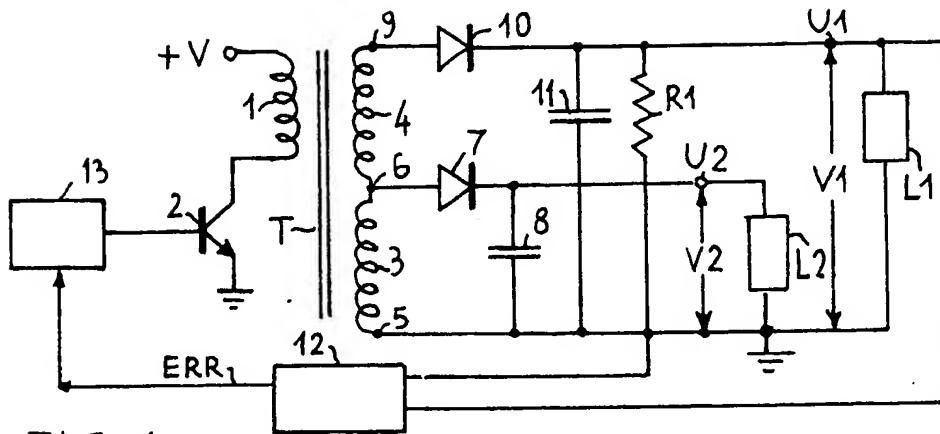


FIG. 1

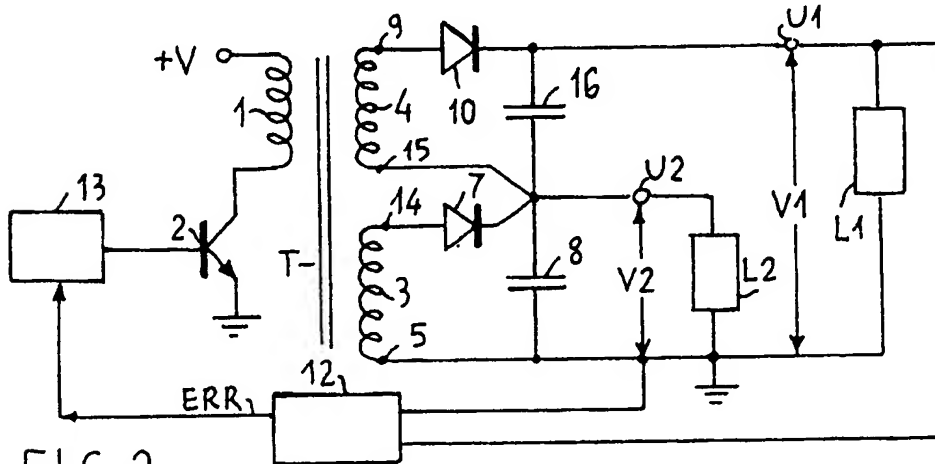


FIG. 2

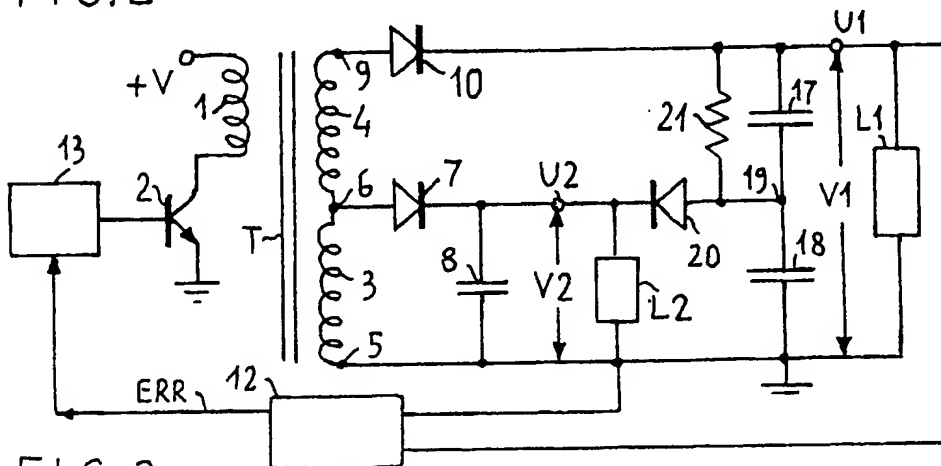


FIG. 3



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EUROPEAN SEARCH REPORT

Application Number

EP 90 11 8225

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	GB-A-2166270 (YOKOGAWA HOKUSHIN ELECTRIC CORPORATION) * the whole document *	1	H02M3/28
A	US-A-4669036 (P. M. COWETT) * column 5, line 3 - column 5, line 12; figure 3 *	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H02M
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 06 NOVEMBER 1990	Examiner GARDELLA S
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